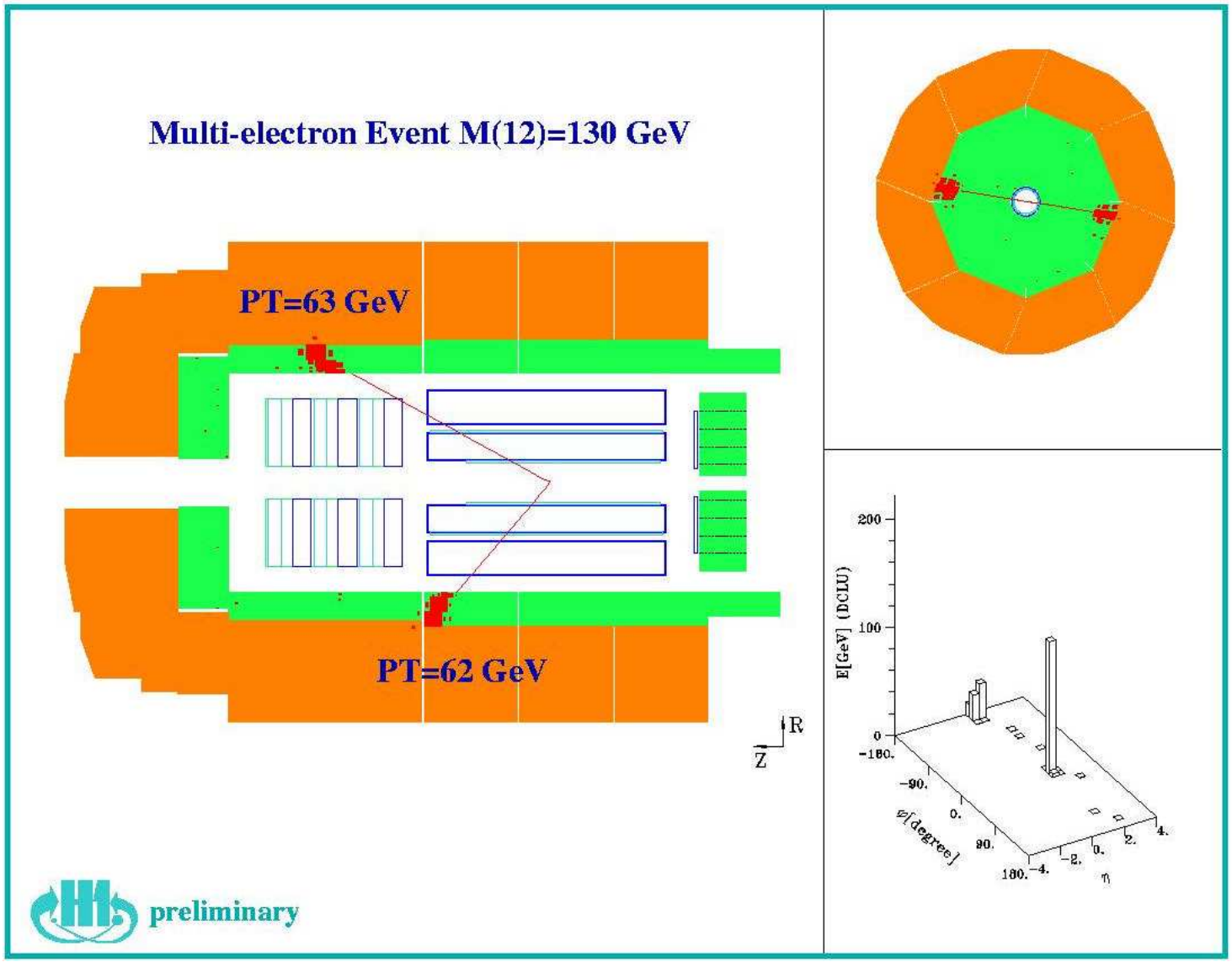
DIS 2002, Krakow, April 30th- May 4th 2002

HIGH-P_T MULTI-ELECTRON PRODUCTION AT HERA

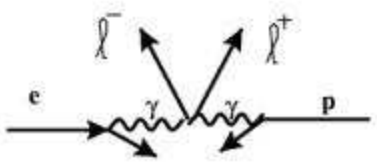
Claude Vallée

CPPM Marseille

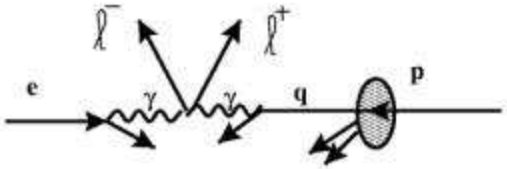
for


Multi-electron Event M(12)=130 GeV
PT=63 GeV
PT=62 GeV
R
Z
preliminary
E[GeV] (DCLU)
200
100
0
-180.
-90.
0.
90.
180.
φ[degree]
-4.
-2.
0.
2.
4.
η

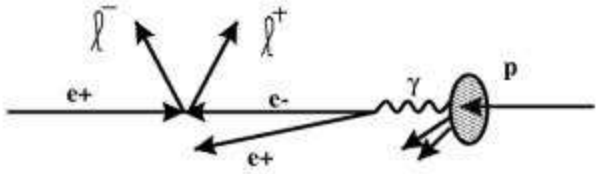
THE SM PROCESSES AND THEIR SIMULATION



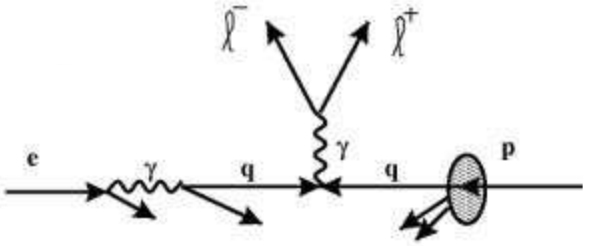
elastic γγ



inelastic γγ



Cabibbo-Parisi



Drell-Yan (negligible)

LPAIR: elastic + inelastic γγ without interference terms

GRAPE: idem + interference terms + ISR + FSR
+ internal conv. ($\gamma \rightarrow e^+e^-$) + Cabibbo-Parisi + EW processes

GRAPE extra diagrams → ~20% σ increase (40% on Z^0 pole, small effect above)

GRAPE with interface to the H1 detector is used in the analysis

ELECTRON IDENTIFICATION

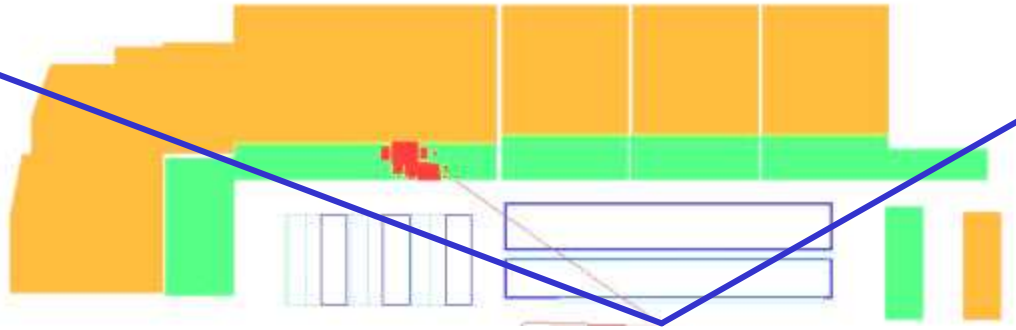
tuned for efficient fake-e rejection and accurate performance control

central region:

isolated electromagnetic shower, E > 5 GeV
with associated isolated good central track
+ shower-track momentum match

20°

150°



forwards:
isol. e.m. shower
E > 10 GeV
no track req.

e →

backwards:
e.m. shower
E > 5 GeV
no track req.

← p

+ isolation of electrons and jets from each other

EVENT SELECTION

total sample :

1 central electron with $P_T > 10$ GeV
+ 1 central electron with $P_T > 5$ GeV
+ any other electron with no explicit P_T cut

electrons ordered in decreasing P_T: $P_T^{e1} > P_T^{e2}$ ($> P_T^{e3}$)

subsamples :

2e: exactly 2 visible electrons
3e: exactly 3 visible electrons
$\gamma\gamma \rightarrow e^+e^-$: exactly 2 visible electrons with opposite charges
$E - P_z < 45$ GeV

Full HERA I data analysed (115 pb^{-1})

36.5 pb^{-1} of e^+p collisions at $\sqrt{s} = 300$ GeV
65.1 pb^{-1} " 318 "
13.6 pb^{-1} " e^-p " 318 "

RESULTS

H1 Preliminary 115 pb^{-1} Multi-electron Analysis

Selection	DATA	SM	GRAPE	NC-DIS + Compton
Visible 2e	**105**	118.2 ± 12.8	93.3 ± 11.5	25.0 ± 5.5
Visible 3e	**16**	21.6 ± 3.0	21.5 ± 3.0	0.1 ± 0.1
Visible 4e or more	**0**	0.1 ± 0.0	0.1 ± 0.0	0.0 ± 0.0
$\gamma\gamma \to e^+e^-$ subsample	**41**	48.3 ± 6.1	46.4 ± 6.1	1.9 ± 0.9

main systematics →

calo energy scale (0.5 – 3 %)	**1 %**
tracker efficiency (3 – 15 %)	**7 %**
trigger efficiency + luminosity	**3 %**
NC/Compton background (20 %)	**3 %**
theoretical uncertainties	**10 %**

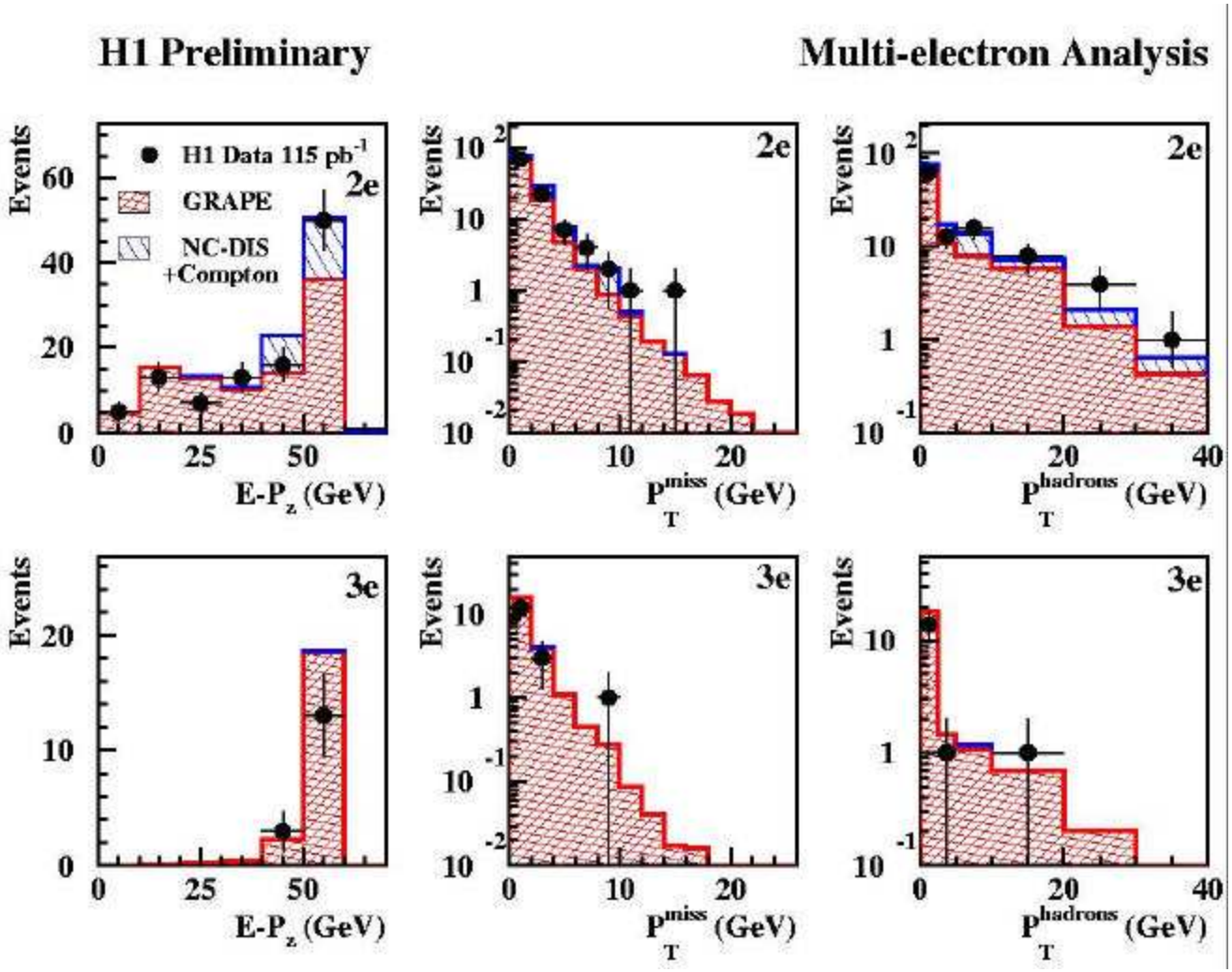
← effect on total prediction

GLOBAL EVENT VARIABLES

- longitudinal momentum as expected for 2e and 3e
- low missing P_T
- inelasticity spectrum well described

2e →

3e →

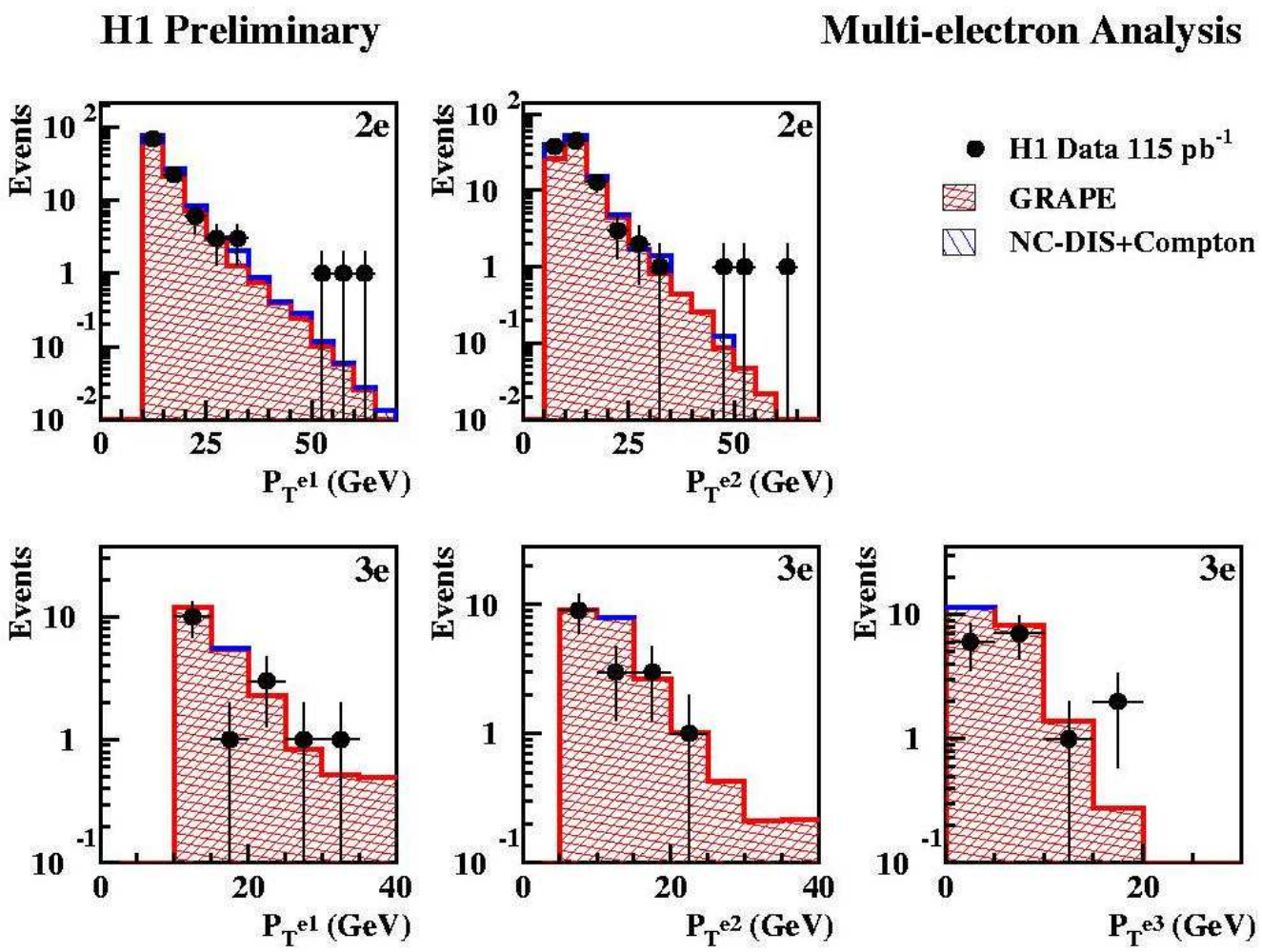


ELECTRON TRANSVERSE MOMENTA

- steep spectra
- three 2e events sticking out at $P_T^{e1,e2} \cong 50$ - 60 GeV

2e →

3e →

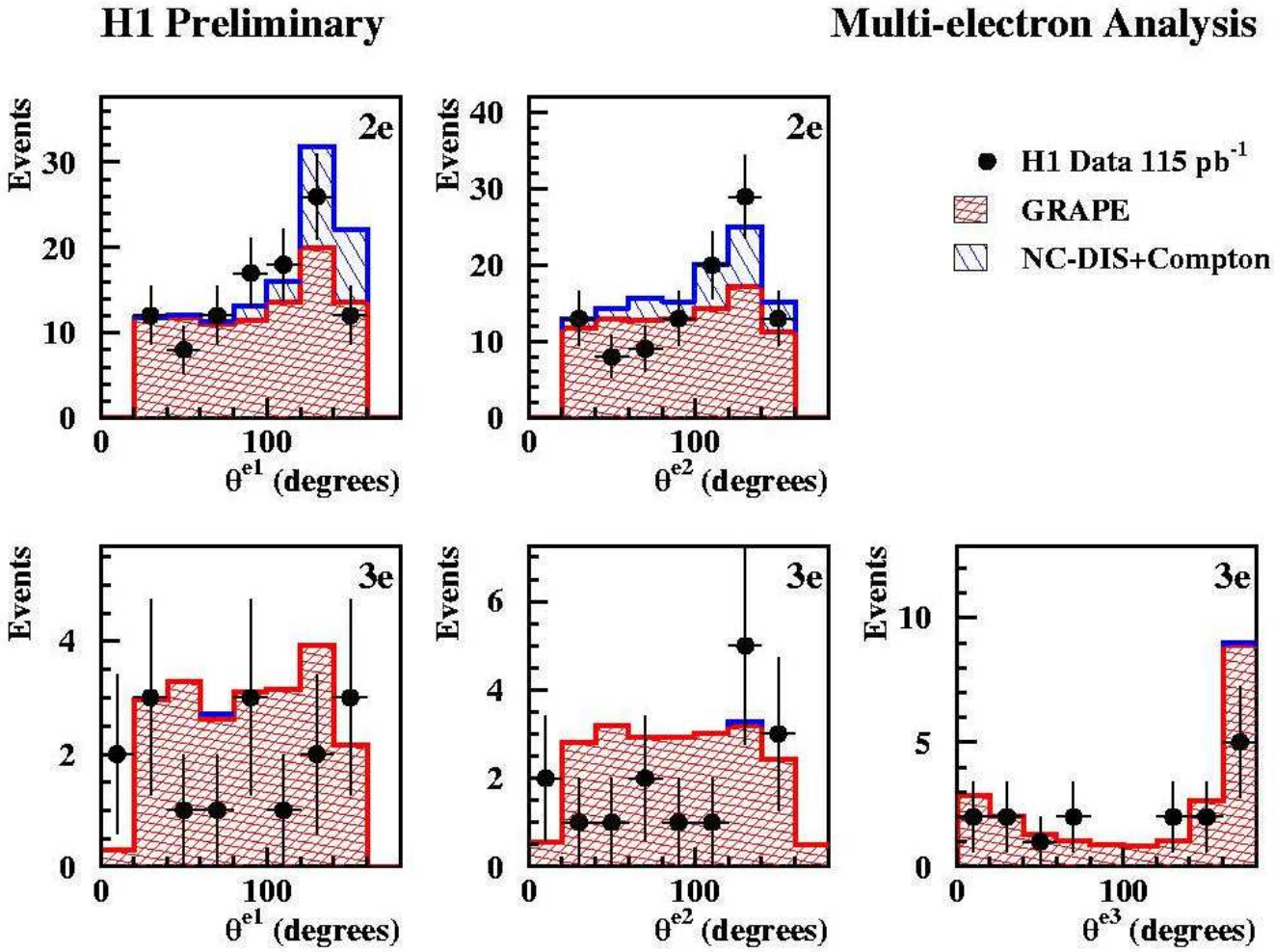


ELECTRON POLAR ANGLES

uniform distributions except for θ^{e3}

2e →

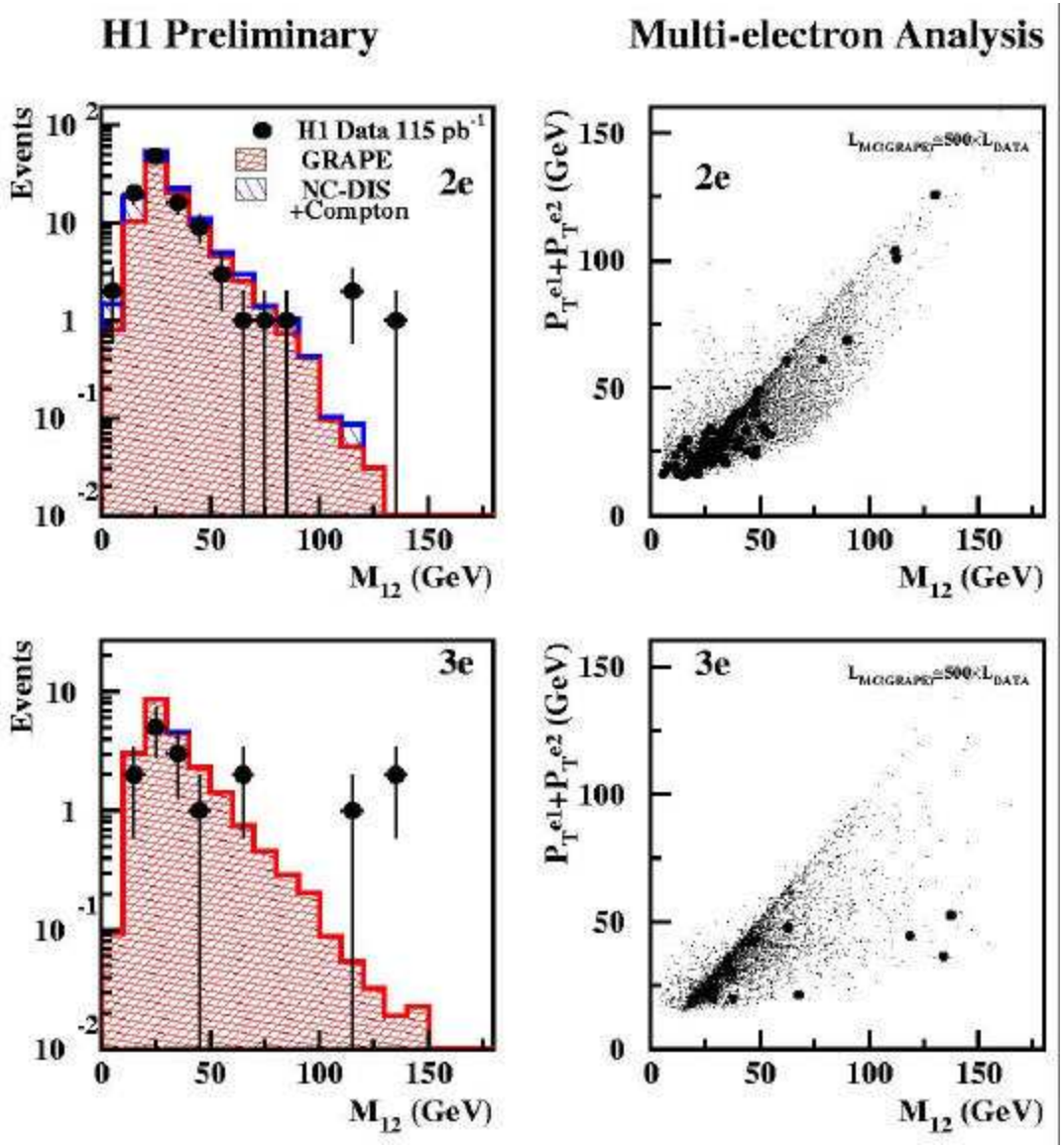
3e →



MASS OF THE 2 HIGHEST-P_T ELECTRON PAIR

2e →

3e →



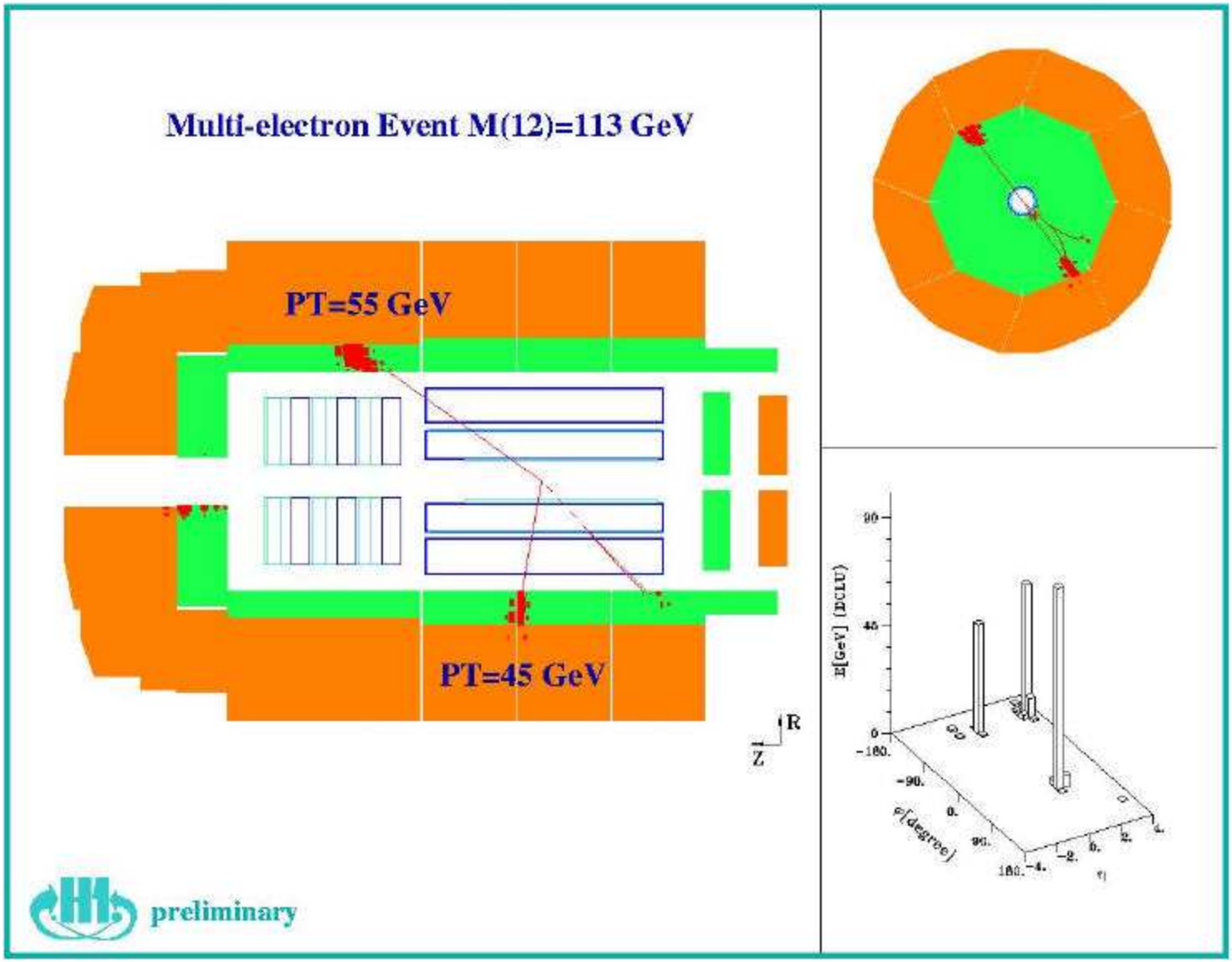
← the 3 high-mass pairs have also high P_T

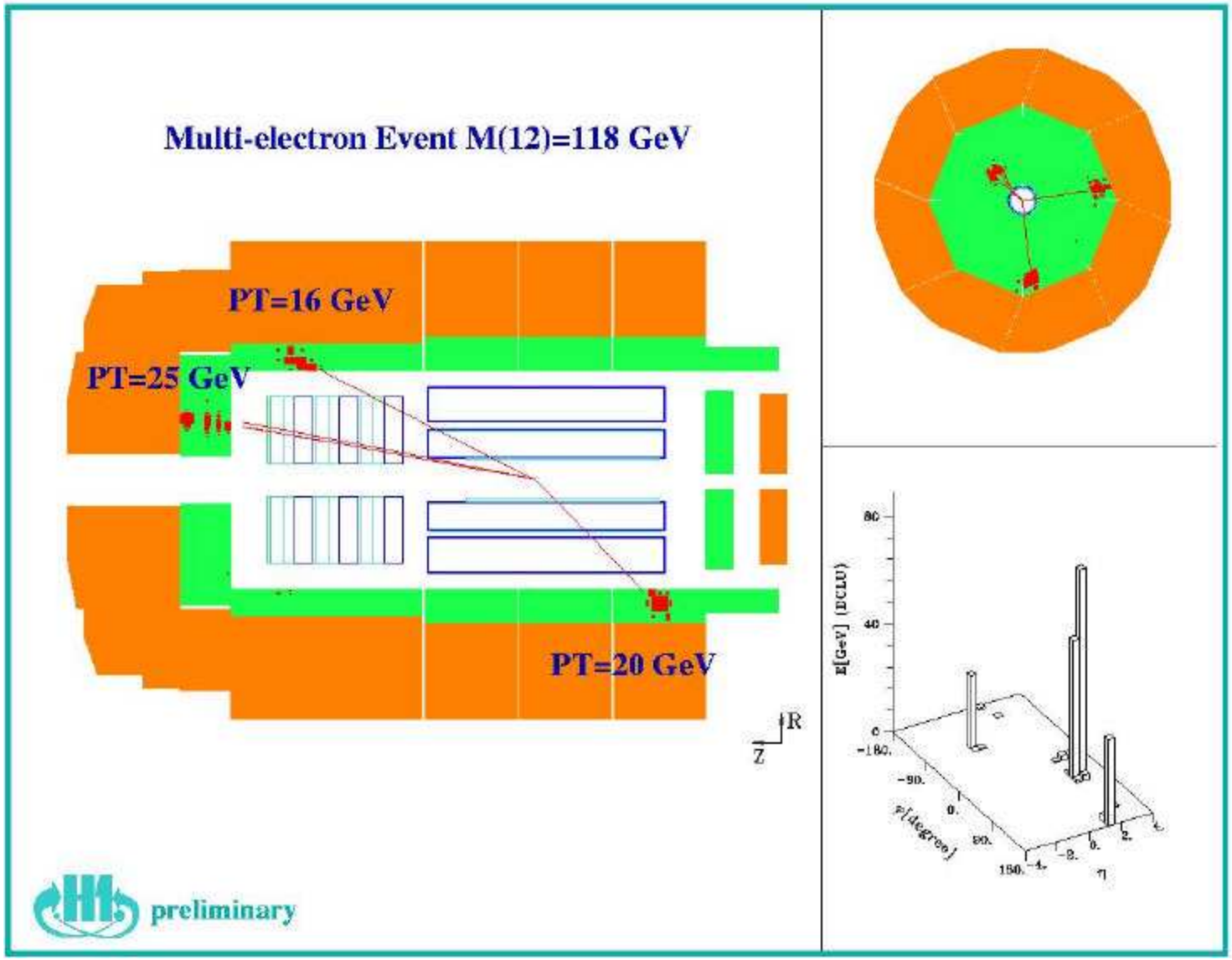
the 3 high-mass pairs have a bwd-fwd topology ←

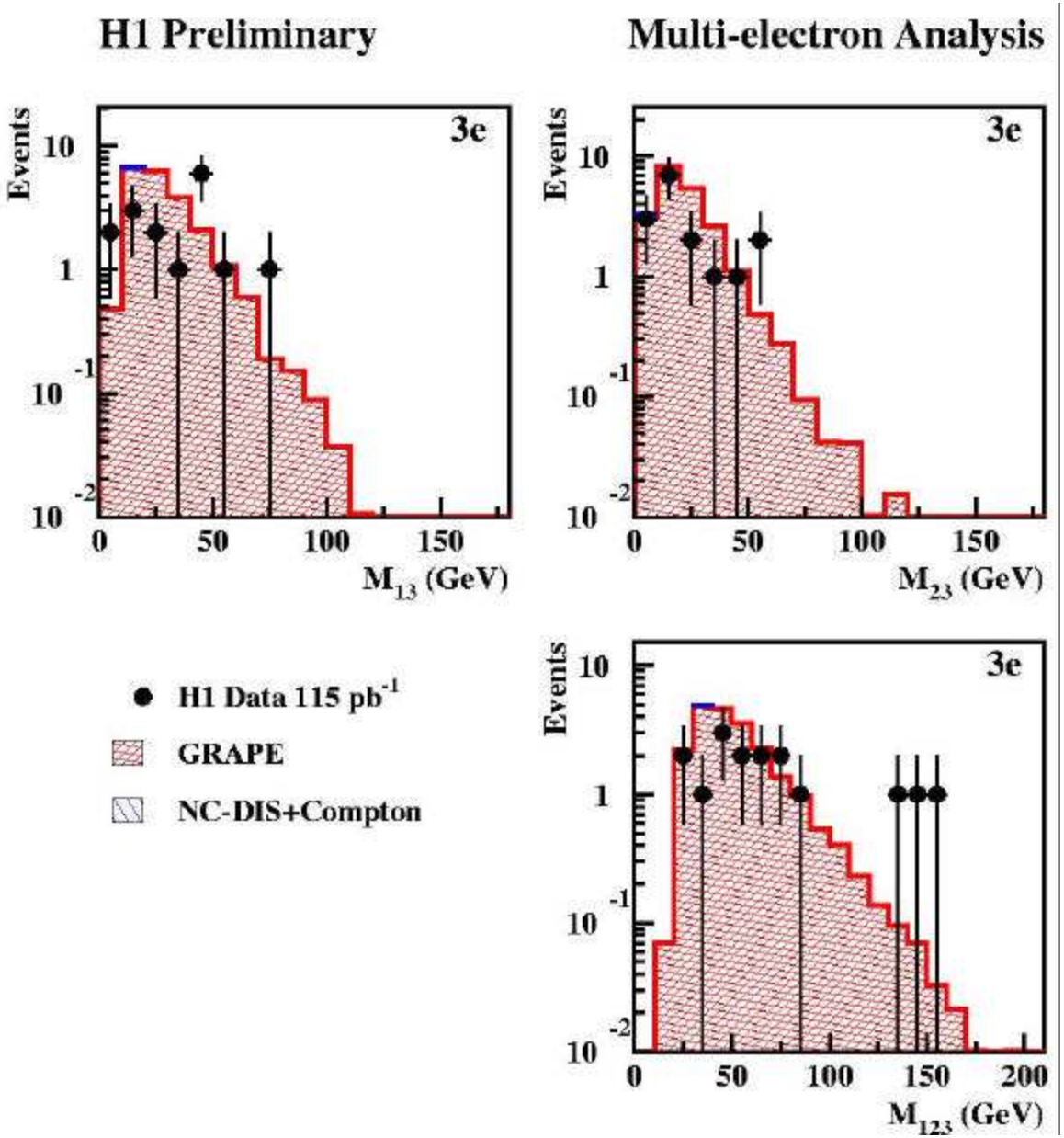
EVENT YIELDS AT HIGH M_{12}

H1 Preliminary 115 pb^{-1} **Multi-electron Analysis**

Selection	DATA	SM	GRAPE	NC-DIS + Compton
Visible 2e $M(12) > 100$	**3**	0.25 ± 0.05	0.21 ± 0.04	0.04 ± 0.03
Visible 3e $M(12) > 100$	**3**	0.23 ± 0.04	0.23 ± 0.04	0.00 ± 0.00


Multi-electron Event M(12)=113 GeV
PT=55 GeV
PT=45 GeV
R
Z
preliminary
E[GeV] (DCLU)
90
45
0
-180.
-90.
0.
90.
180.
φ[degree]
-4.
-2.
0.
2.
η


Multi-electron Event M(12)=118 GeV
PT=16 GeV
PT=25 GeV
PT=20 GeV
R
Z
E[GeV] (DCLU)
80
40
0
-180.
-90.
0.
90.
150.
φ[degree]
-4.
-2.
0.
2.
η
preliminary

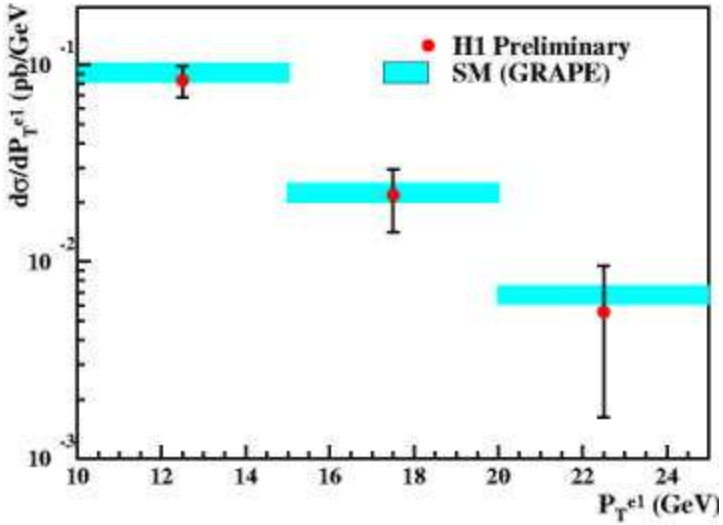


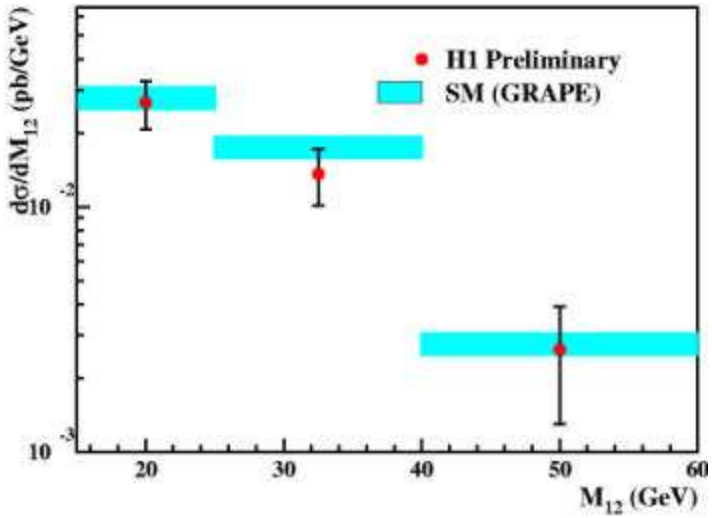
3-ELECTRON VARIABLES

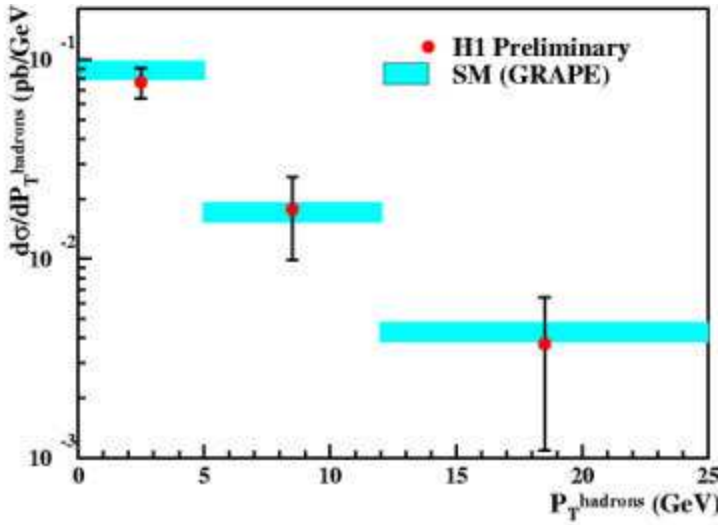
no high masses for other pair combinations

$e(\gamma\gamma)p \rightarrow e^+e^- X$ CROSS SECTIONS

$P_T^{e1} > 10$ GeV, $P_T^{e2} > 5$ GeV, $20^o < \theta^{e1,e2} < 150^o$, $y < 0.82$, $Q^2 < 1$ GeV





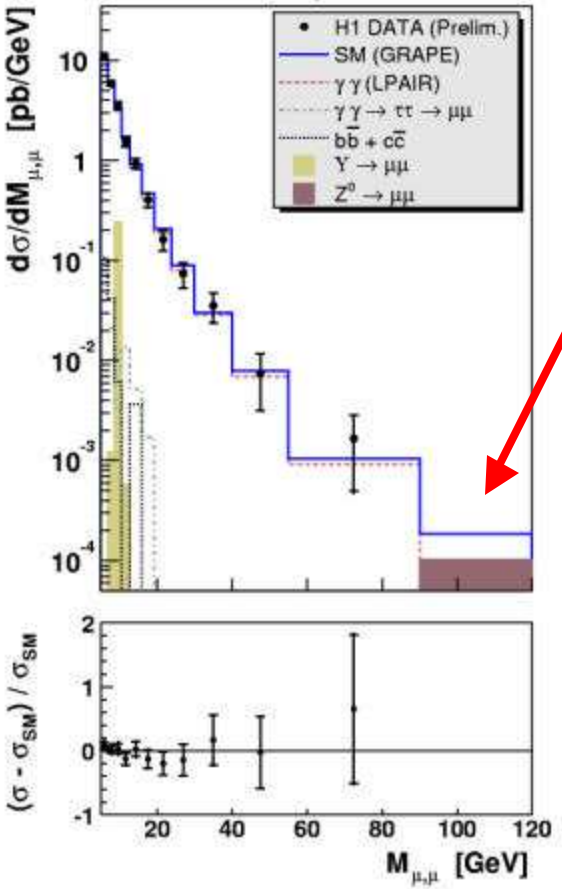


- good agreement with SM
- good description of inelasticity confirms the $\gamma\gamma$ background understanding for events with isolated leptons and missing transverse momentum

COMPARISON TO DI-MUON RESULTS

(see Boris Leissner's talk in multi-hadron session)

ep →μμ X



No μμ event seen with M > 100 GeV

extrapolation from
central 2e's with M > 100 GeV:

$$3\ ee \times \frac{L\varepsilon(\mu\mu)}{L\varepsilon(ee)} \cong 1\ \mu\mu \text{ expected}$$

comparison not yet conclusive

SUMMARY

multi-electron production has been measured in e-p collisions
for electron P_T's up to ~50 GeV and electron pair masses up to ~100 GeV

good overall agreement is found with the Standard Model

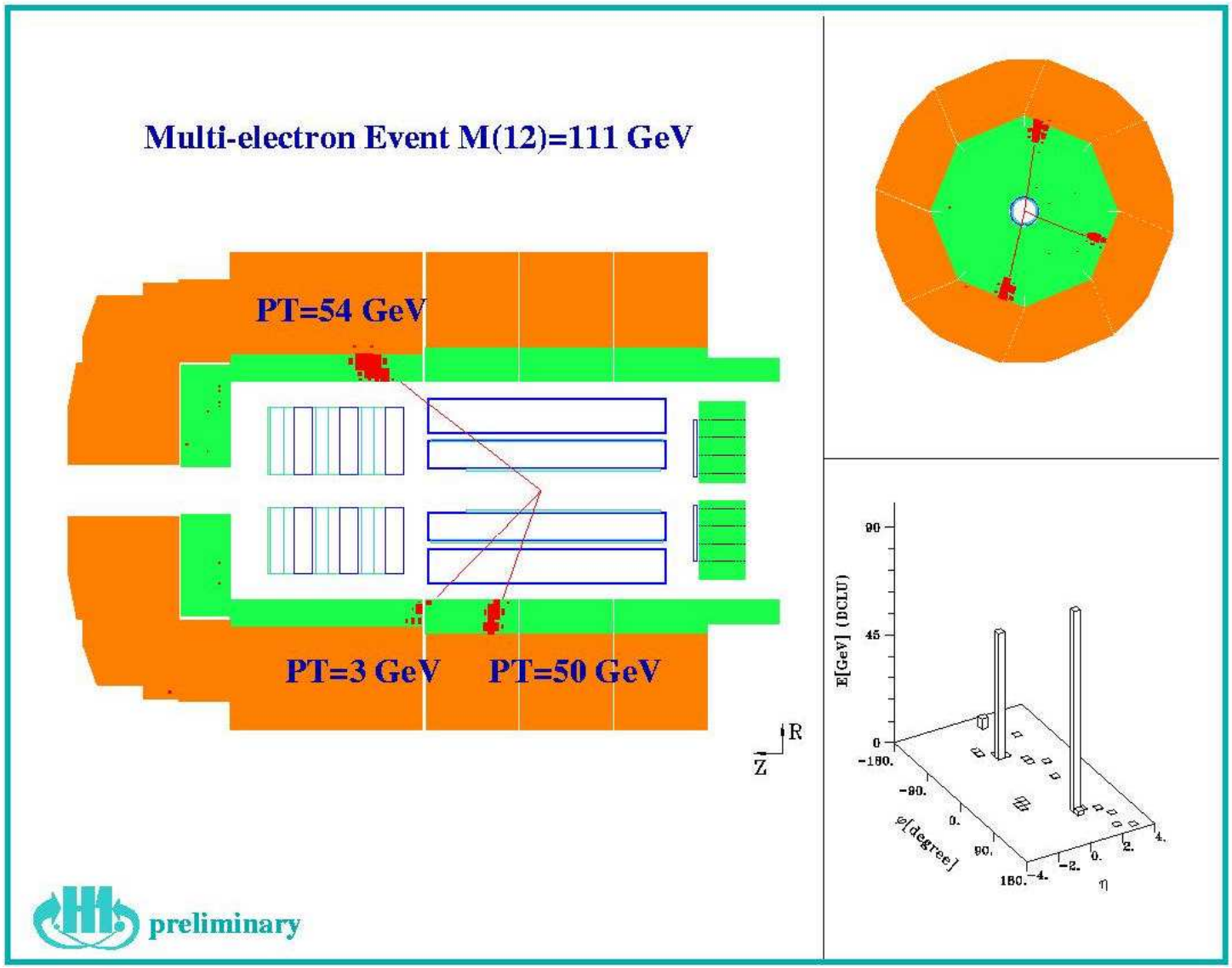
6 events are seen with electron pair masses above 100 GeV

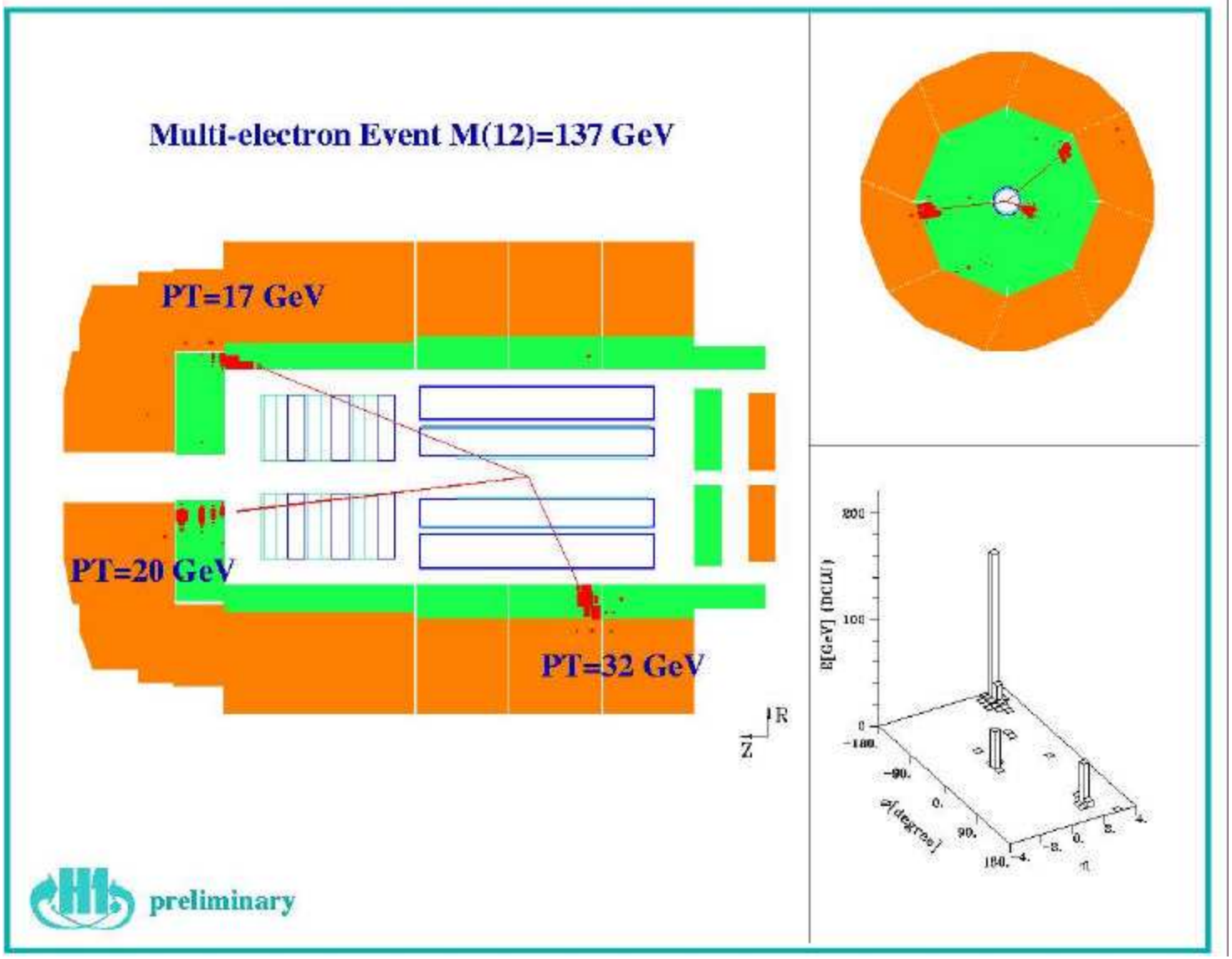
	data	SM
visible 2e M_{12} > 100 GeV :	3	0.25 ± 0.05
" 3e " :	3	0.23 ± 0.04

LOOKING FORWARD TO HIGHER LUMINOSITY AND FURTHER INVESTIGATION OF THE EXCESS

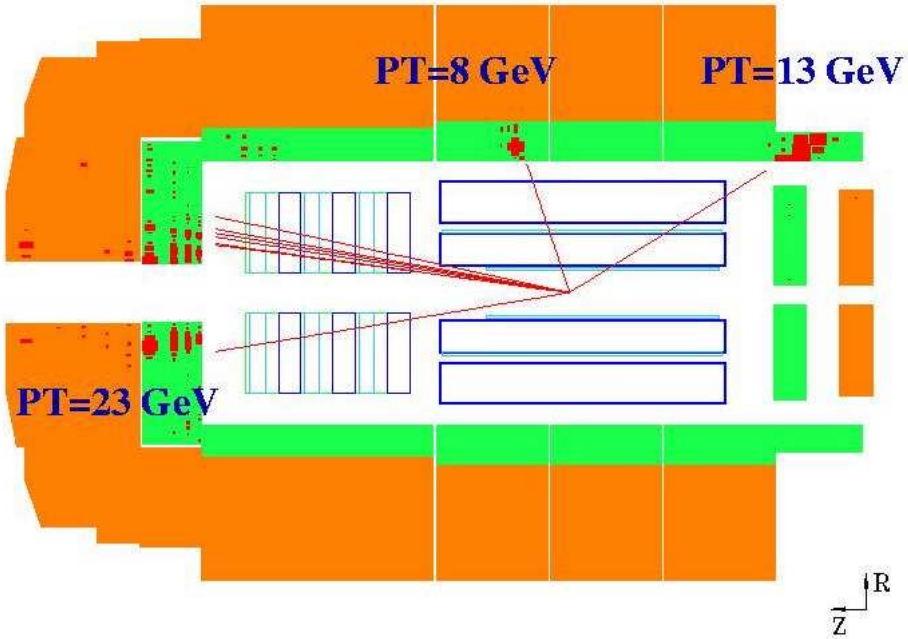
ADDITIONAL SLIDES

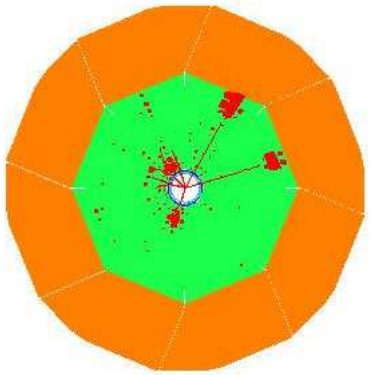
- Event Displays of the 3 other high mass multi-electron events
- LPAIR/GRAPE detailed comparison
- control studies of experimental effects

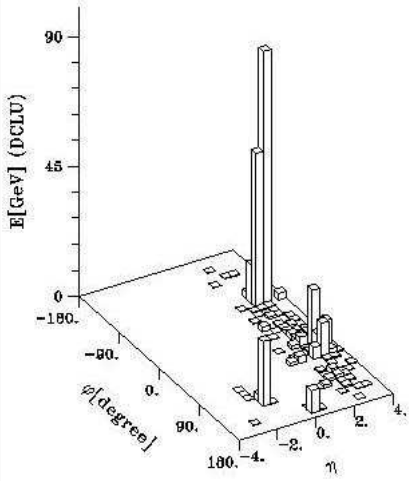

Multi-electron Event M(12)=111 GeV
PT=54 GeV
PT=3 GeV
PT=50 GeV
R
Z
preliminary
E[GeV] (DCLU)
90
45
0
-180.
-90.
0.
90.
180.
φ[degree]
-4.
-2.
0.
2.
4.
η


Multi-electron Event M(12)=137 GeV
PT=17 GeV
PT=20 GeV
PT=32 GeV
R
Z
preliminary

Multi-electron Event M(12)=135 GeV







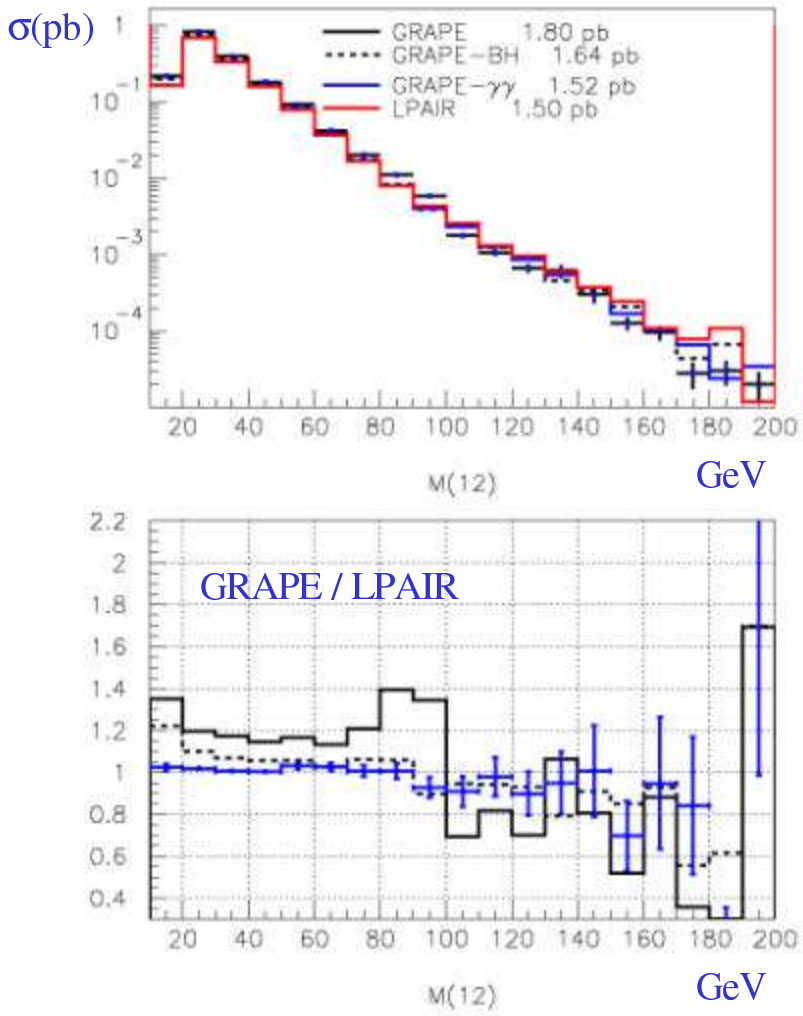
preliminary

GRAPE-LPAIR COMPARISON

Good agreement for LPAIR diagrams

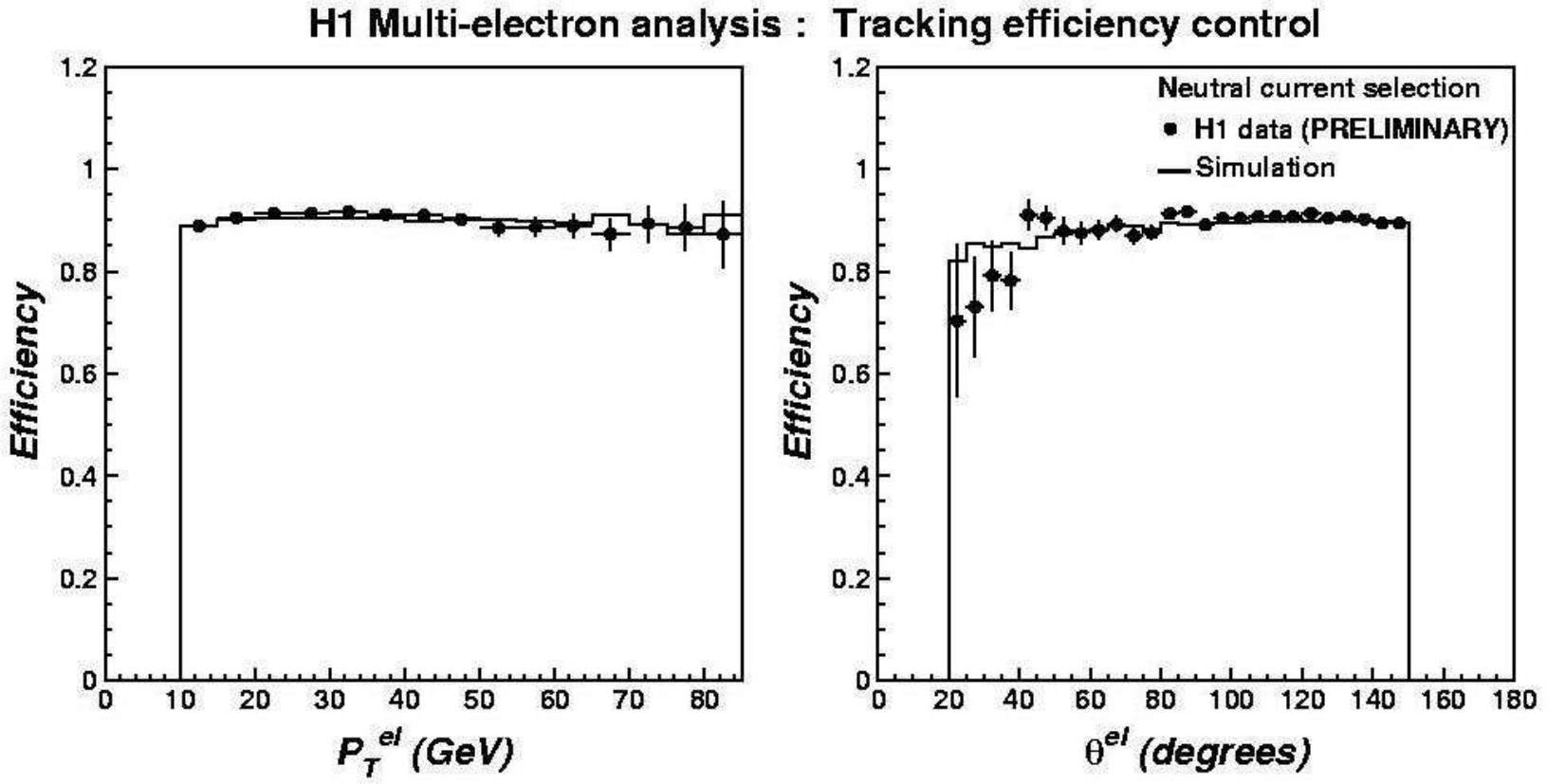
Effect of GRAPE extra diagrams:

- 20% total cross-section increase
- 40% cross-section increase
  at low mass (internal conversions)
  and at the Z0 mass (EW effects)
- small absolute effect
  at the highest masses



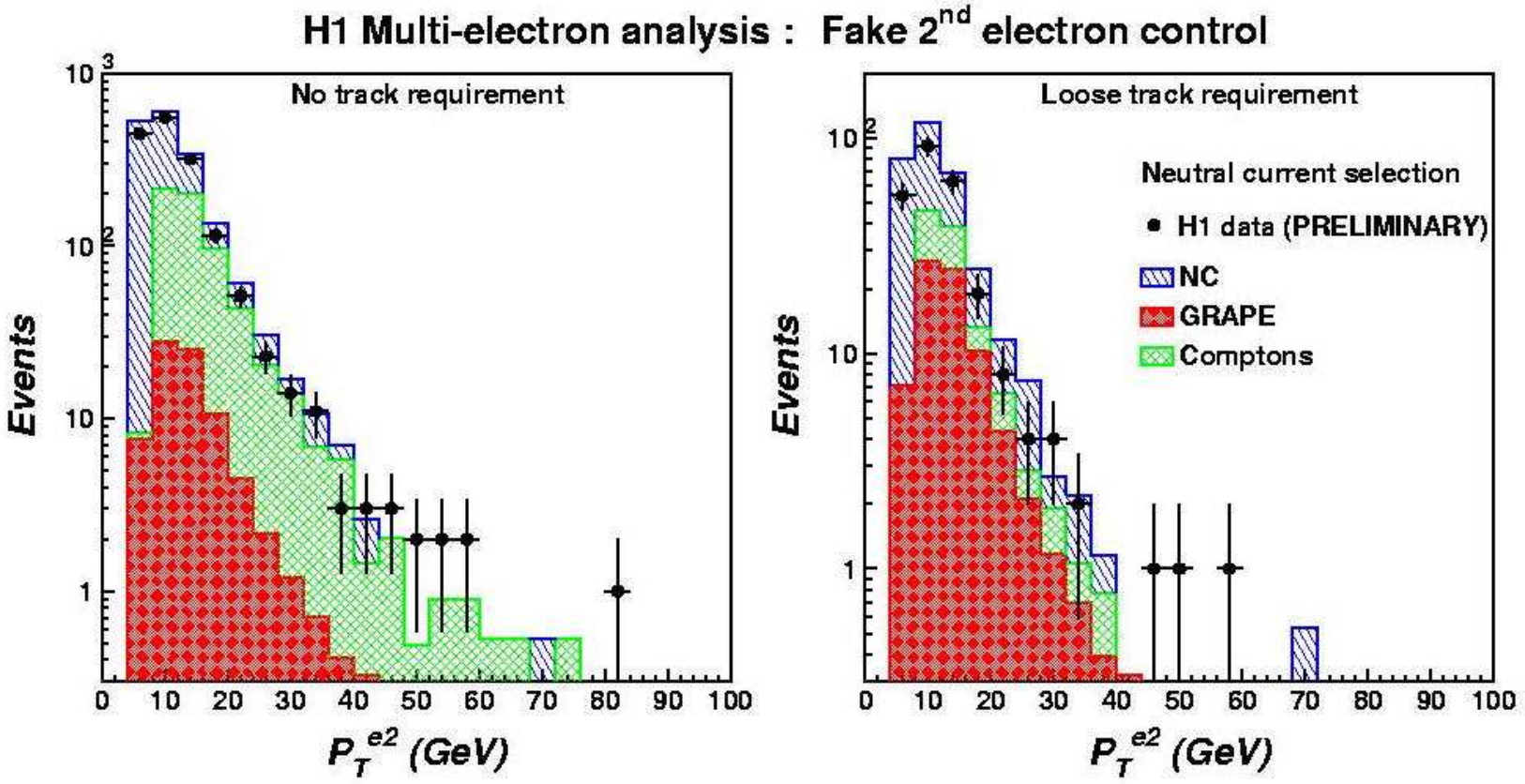
TRACKING EFFICIENCY

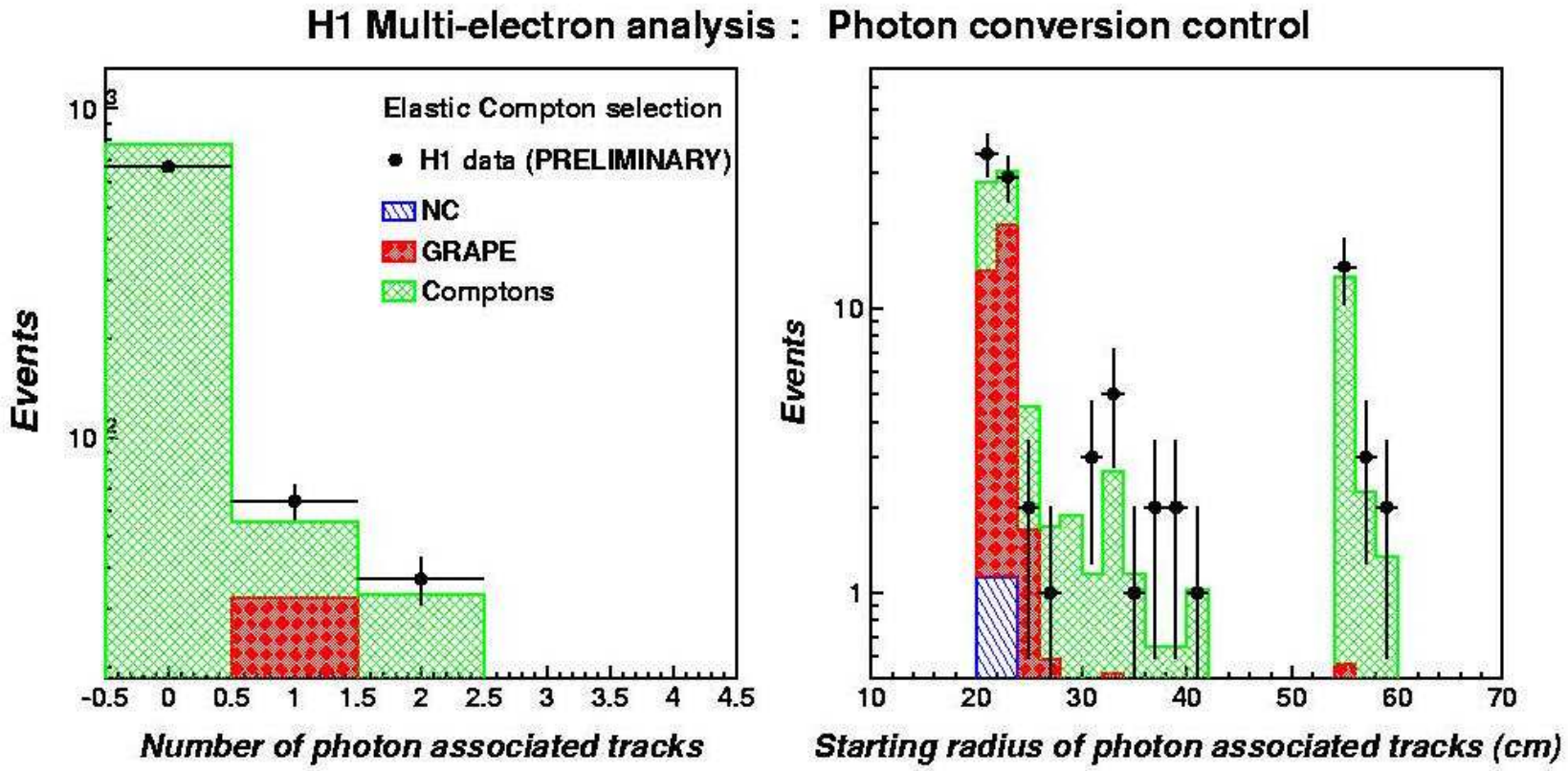
measured with electron track unbiased Neutral Currents



FAKE ELECTRON BACKGROUND

controlled by relaxing e2 identification criteria in Neutral Currents



CONVERTED PHOTON BACKGROUND

controlled with photon track unbiased elastic Comptons